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Standard Method of Test for
INTERNATIONAL HARDNESS OF VULCANIZED RUBBER[1]

This Standard is issued under the fixed designation D 1415; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

This method has been approved by the Department of Defense to replace method 3061 of Federal Test Method Standard No. 601 and for listing in the DoD Index of Specifications and Standards. Future proposed revisions should be coordinated with the Federal Government through the Army Materials and Mechanics Research Center, Watertown, Mass. 02172.

NOTE—The title was changed editorially in September 1969.

INTRODUCTION

The International hardness test is based on measurement of the penetration of a rigid ball into the rubber specimen under specified conditions. The measured penetration is converted into International Rubber Hardness degrees, the scale of degrees being so chosen that 0 represents a material having an elastic modulus of zero, and 100 represents a material of infinite elastic modulus. The scale chosen also fulfills the following conditions over most of the normal range of hardness:

(*1*) One International Rubber Hardness degree always represents approximately the same proportionate difference in Young's modulus, and

(*2*) Readings in International Rubber Hardness degrees are approximately the same as those given by the durometer (ASTM Method D 2240).[2]

For substantially elastic isotropic materials like well-vulcanized natural rubbers, the hardness in International Rubber Hardness degrees bears a known relation to Young's modulus, although for markedly plastic or anisotropic rubbers the relationship will be less precisely known.

The relation between the difference of penetration and the hardness expressed in International Rubber Hardness degrees is based on the following:

(*1*) The known relation[3] between penetration and Young's modulus for a perfectly elastic isotropic material; namely,

$$F/M = 0.00017\, R^{0.65} P^{1.35}$$

where:

F = indenting force, kgf,
M = Young's modulus, kgf/cm^2,
R = radius of ball, cm, and
P = penetration in hundredths of millimeters.

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[1] This method is under the jurisdiction of ASTM Committee D-11 on Rubber-Like Materials and is the direct responsibility of Subcommittee D-11.10 on Physical Testing.

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This method is identical in substance with the revision of ISO Recommendation R 48 under consideration by the International Organization for Standardization.

[2] *1974 Annual Book of ASTM Standards*, Part 37.

[3] This relation is approximate and is included as an indication.

(*2*) Use of a probit (integrated normal error) curve to relate $\log_{10} M$ and hardness in International Rubber Hardness degrees, as shown in Fig. 1. This curve is defined as follows:

The value of $\log_{10} M$ corresponding to the midpoint of the curve is equal to 1.372, that is, $M = 23.55$ kgf/cm^2 or 335 psi.

The maximum slope is equal to 57 International Rubber Hardness degrees per unit increase in $\log_{10} M$.

1. Scope

1.1 This method covers the measurement of the difference between the depths of penetration of the ball into the rubber under a small initial load and a large final load. Two procedures are given to accommodate specimens of different dimensions. The standard test is intended to be used on specimens greater than 4 mm in thickness, preferably 8 to 10 mm. The micro-test is used on specimens less than 4 mm in thickness, on specimens thicker than 4 mm having lateral dimensions less than those specified for the standard test, or on rubber articles that do not have flat surfaces suitable for making the standard test. In both procedures, the hardness in International Rubber Hardness degrees (IRHD) is derived from the difference in penetrations and a table or graph constructed from the table. In the micro-test, the difference in penetration must first be multiplied by scale factor 6. Alternatively, the penetration-measuring instrument may be calibrated directly in IRHD.

2. Apparatus

2.1 The essential parts of the apparatus are as follows, the appropriate dimensions and loads being given in Table 1:

2.1.1 *Vertical Plunger* terminating in a rigid ball.

2.1.2 *Load Applicator*—Means for applying a minor load and a major load to the ball: the weight of the plunger and of any fittings attached to it and the force of any spring acting on it shall be included in the minor and major loads in order that the loads actually applied to the ball shall be as specified.

2.1.3 *Measuring Device*—A mechanical, optical, or electrical device graduated either in standard units of length or in International Rubber Hardness degrees for measuring the increase in depth of penetration of the plunger caused by the major load.

2.1.4 *Foot*—A flat, annular-shaped foot that is rigidly fastened to the penetration-measuring device and normal to the axis of the plunger, and which during the test is forced against the specimen in order to determine accurately the position of the upper surface.

2.1.5 *Vibrating Device*—Means, for example, an electrically operated buzzer, for gently vibrating the apparatus to overcome any slight friction; this should not exceed 5 percent of the minor load. This device may be omitted on apparatus without any friction.

3. Test Specimen

3.1 Tests intended to be comparable must be made on specimens of the same thickness that have smooth, flat, and parallel upper and lower surfaces. Two pieces of rubber, but not more than two, may be superimposed to obtain the required thickness. The dimensions of the specimen depend on the tester used to measure the hardness.

3.2 *Standard Tester*—The standard specimen shall be between 8 and 10 mm in thickness; nonstandard specimens may be either thicker or thinner but in no case less than 4 mm thick. The lateral dimensions of both standard and nonstandard specimens shall be not less than 20 mm, and no test shall be made at a distance from the edge of the specimen less than the appropriate distance shown in Table 2.

3.3 *Micro Tester*—The standard specimen for the micro test shall be between 2 and 2.5 mm in thickness; nonstandard specimens may be either thicker or thinner but in no case less than 1 mm thick. The lateral dimensions of both standard and nonstandard specimens shall be such that no test is made at a distance from the edge of less than 2 mm. When specimens thicker than 4 mm are tested on the micro tester because lateral dimensions or area of flatness do not permit testing on a standard tester, the test shall be made at a distance from the edge as great as possible.

Curved specimens, for example, O-rings, may be tested with the micro tester, but the values obtained may not be comparable to those obtained with flat specimens.

4. Test Temperature

4.1 The test shall be normally carried out at the Standard Laboratory Temperature prescribed in ASTM Specification E 171, for Standard Atmospheres for Conditioning and Testing Materials.[4] Before testing, the specimens shall be maintained for at least 3 h immediately prior to test at the conditions prescribed in Specification E 171 for the Standard Laboratory Atmosphere. When tests are made at higher or lower temperatures, the specimens shall be maintained at the conditions of test for a period of time sufficient to reach temperature equilibrium with the testing chamber.

5. Procedure

5.1 Condition the specimen in accordance with Section 4. Slightly dust the upper and lower surfaces of the test specimen with talc. Support the specimen on a horizontal rigid surface, and lower the foot to rest on the surface of the specimen. Press the plunger, with the minor load on the indenting ball, vertically on to the specimen for 5 s.

5.2 If the gage is graduated directly in International Rubber Hardness degrees, turn the bezel of the gage so that the pointer indicates 100 (exercise care to avoid exerting any vertical pressure on the gage). Add the major load to the plunger and maintain the total load on the ball for 30 s. (Note). Record the reading on the gage as the hardness in International Rubber Hardness degrees.

NOTE—During the loading periods the apparatus shall be gently vibrated to overcome any friction.

5.3 If the measuring device is graduated in metric or inch units, record the movement of the plunger caused by application of the major load for 30 sec. If the micro tester is used, multiply this movement by the scale factor of 6. Convert the value obtained into International Rubber Hardness degrees by using Table 3 or a graph constructed therefrom.

5.4 Make one measurement at each of three or five different points distributed over the specimen. Take the median of these measurements rounded to the nearest IRHD for the hardness value.

6. Report

6.1 The report shall include the following:

6.1.1 Hardness, expressed in International Rubber Hardness degrees (IRHD),

6.1.2 Dimensions of specimen and number of pieces, that is, one or two,

6.1.3 Type of surface tested, that is, molded, buffed, or otherwise,

6.1.4 Type of tester used, that is, standard or micro, and

6.1.5 Temperature of test.

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[4] *1974 Annual Book of ASTM Standards*, Part 41.

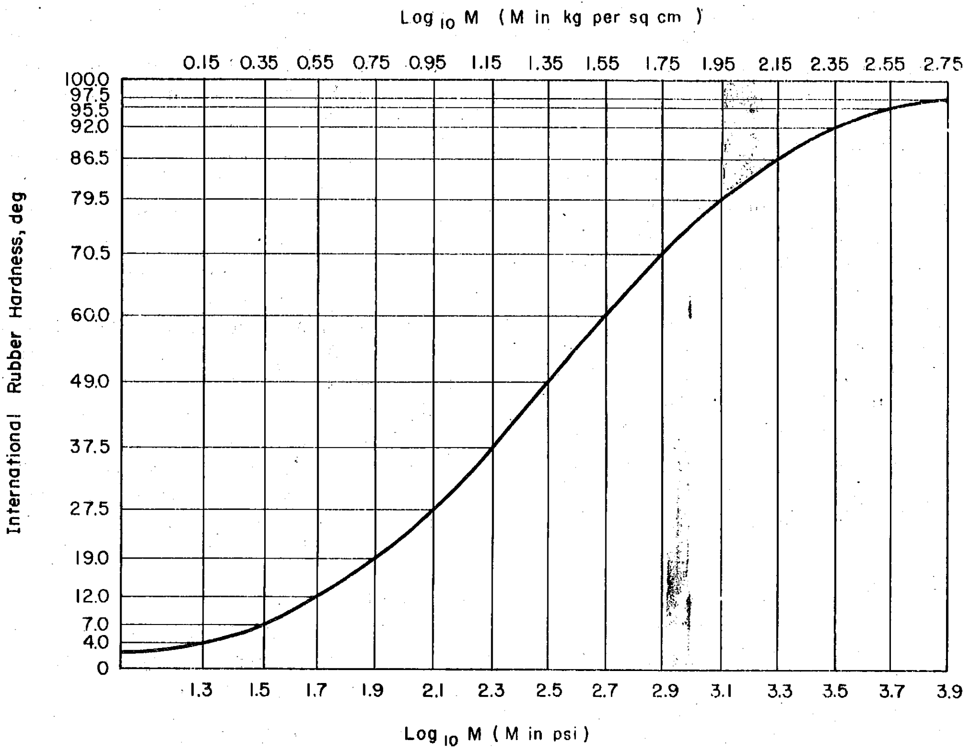

FIG. 1 Probit Curve to Relate Log$_{10}$ M and the Hardness in International Rubber Hardness Degrees.

TABLE 1 Apparatus Requirements

	Standard Testers		Micro Tester
Diameter of ball, mm	2.38 ± 0.01	2.50 ± 0.01	0.395 ± 0.005
Minor load on ball, gf[a]	30 ± 2	30 ± 2	0.85 ± 0.05
Major load on ball, gf	534 ± 1	550 ± 1	14.85 ± 0.05
Total load on ball, gf	564 ± 3	580 ± 3	15.70 ± 0.10
Outside diameter of foot, mm	20 ± 1	20 ± 1	3.35 ± 0.15
Inside diameter of foot, mm	6 ± 1	6 ± 1	1.00 ± 0.15
Load on foot, gf[b]	850 ± 150	850 ± 150	24 ± 3[c]

[a] Includes frictional forces in apparatus.

[b] The load should be adjusted within these limits to the actual area of the foot so that the pressure on the specimen is 300 ± 50 gf/cm^2.

[c] Load on foot during application of total load on ball; load on foot during application of minor load on ball, 21 gf minimum, 42 gf maximum.

TABLE 2 Minimum Distance From Edge of Specimen at which Test is Made

Total Thickness of Specimen		Minimum Distance from Edge	
mm	in.	mm	in.
4	0.16	7.0	0.28
6	0.25	8.0	0.31
8	0.3	9.0	0.35
10	0.4	10.0	0.40
15	0.6	11.5	0.45
25	1.0	12.5	0.50

TABLE 3 Relation Between International Rubber Hardness Degrees (IRHD) and Penetrations Differences

IRHD	Movement of Plunger		IRHD	Movement of Plunger		IRHD	Movement of Plunger		IRHD	Movement of Plunger	
	mm	mils		mm	mils		mm	mils		mm	mils
28	1.934	76.1	47	1.055	41.5	66	0.589	23.2	85	0.280	11.0
29	1.867	73.5	48	1.024	40.3	67	0.570	22.5	86	0.266	10.5
30	1.803	71.0	49	0.994	39.1	68	0.552	21.7	87	0.251	9.9
31	1.743	68.6	50	0.964	38.0	69	0.534	21.0	88	0.237	9.3
32	1.685	66.4	51	0.936	36.8	70	0.516	20.3	89	0.223	8.8
33	1.630	64.2	52	0.908	35.8	71	0.498	19.6	90	0.209	8.2
34	1.578	62.1	53	0.881	34.7	72	0.481	18.9	91	0.195	7.7
35	1.528	60.1	54	0.855	33.7	73	0.464	18.3	92	0.180	7.1
36	1.479	58.2	55	0.830	32.7	74	0.447	17.6	93	0.166	6.5
37	1.433	56.4	56	0.805	31.7	75	0.431	17.0	94	0.151	5.9
38	1.389	54.7	57	0.781	30.8	76	0.415	16.3	95	0.135	5.3
39	1.346	53.0	58	0.758	29.8	77	0.399	15.7	96	0.119	4.7
40	1.305	51.4	59	0.735	28.9	78	0.384	15.1	97	0.102	4.0
41	1.265	49.8	60	0.713	28.1	79	0.368	14.5	98	0.083	3.3
42	1.227	48.3	61	0.691	27.2	80	0.353	13.9	99	0.060	2.4
43	1.190	46.9	62	0.670	26.4	81	0.338	13.3	100	0.000	0.0
44	1.155	45.5	63	0.649	25.5	82	0.323	12.7			
45	1.120	44.1	64	0.629	24.7	83	0.309	12.2			
46	1.087	42.8	65	0.609	24.0	84	0.294	11.6			

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